This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

GODFREY LOWELL CABOT SCIENCE LIBRARY
of the Harvard College Library

This book is
FRAGILE
and circulates only with permission.
Please handle with care
and consult a staff member
before photocopying.

Thanks for your help in preserving
Harvard's library collections.

Bmc

Bmw

Henry Worrall
Eastern R.R.

TREATISE

ON

TOPOGRAPHICAL DRAWING,

BY S. E. EASTMAN,

LIEUT. U. S. ARMY.

NEW-YORK:

WILEY AND PUTNAM,

161 Broadway.

1837.

ENG 528.37.2

MAR -6 1912
HARVARD UNIVERSITY
DEPARTMENT OF ENGINEERING.

JUN 20 1917
TRANSFERRED TO
HARVARD COLLEGE LIBRARY

ENTERED, according to Act of Congress, in the year one thousand eight hundred and thirty-seven, in the Clerk's office of the District Court of the Southern District of New-York.

PRINTED BY WILLIAM OSBORN,
88 William-street.

PREFACE.

THE want of a uniform system of topography in this country, has been the cause of much ambiguity in our topographical maps and plans. They have generally been made according to the taste or fancy of draughtsmen, without regard to any system whatever; and in consequence, are not well calculated to furnish that clear and precise information which is expected from them. With a desire to aid in establishing a uniform and permanent system of topography in this country, as well as to render some assistance to the cadets of the Military Academy, in this branch of their studies, the author has hastily compiled the following work.

The system for shading declivities, under a vertical light, and showing the inclination of surfaces by gradations of shade, is founded upon that of Lehman, and by many is considered preferable to the *oblique*, or as it is sometimes called, the *light and shade system*. But, as both can be used to advantage, it seems proper to introduce them in the present work, leaving it to the draughtsman to use that which he can best manage.

Many of the geographical and military signs have been taken from those used in the topographical bureau at Washington; others have been selected from the best French and German works on this subject; and some have been designed to supply deficiencies.

As the barometer may be used to some advantage in topographical surveys of mountainous countries, the formula for determining heights, and an example of its application, have been introduced in the Appendix, that those not acquainted with the

barometic theory may be enabled to use the instrument when required. A table has also been introduced in which the measures of different countries are compared with our own. This will be useful to those who have occasion to copy maps or compare them with each other.

CONTENTS.

	Page.
PREFACE - - - - - - -	iii
CHAPTER I. Definition - - - - -	9
II. Topographical delineation of hills -	10
" The direction of the strokes or shading lines - - - - - -	12
" Method of expressing the inclination of a declivity - - - - -	17
III. Oblique light - - - - -	25
IV. Topographical delineation of rocks -	30
V. Delineation of topographical minutiæ -	33
VI. Method of sketching ground - -	38
VII. Topographical scales - - -	45
VIII. Method of drawing a perspective view from a topographical plan - - -	48
IX. Of the meridian line - - -	51
X. To mark off the meridians and parallel of latitude - - - - -	53
XI. Problems for reducing, enlarging, and copying maps or plans - - -	54
XII. Formation of letters - - -	63

APPENDIX.

To determine heights barometrically - - -	65
Measures of different countries - - -	67

TREATISE

ON

TOPOGRAPHICAL DRAWING.

CHAPTER I.

DEFINITION.

TOPOGRAPHICAL drawing is the art of representing the appearance which the surface of the earth would present to an observer situated above, and looking vertically upon every part of it.

CHAPTER II.

TOPOGRAPHICAL DELINEATION OF HILLS.

HILLS may be represented either by lines, (or strokes,) radiating from the summit, and then diverging into curves so as to represent the various undulations of their surfaces, or by horizontal curves corresponding to the intersection of their surfaces, with a system of horizontal planes. The former method is termed the *vertical system*,—the latter the *horizontal system*.

Figures 1 and 2, Plate I, are specimens of the representation of the same hill by these two modes.

The *vertical system* is generally used, and is preferable for many reasons, among which are the following:

1st. It enables the draughtsman to express more freely the various features of the ground.

2d. Strong, characteristic touches drawn across the vertical lines will express, with effect, a stratum

of rock that frequently occurs in planes parallel or nearly so, to the horizon.

3d. In sketching, more can be expressed with a few lines. It requires but a few divergent lines to show the situation and extent of a hill; horizontal curves at a similar distance would show no connection amongst other curvilinear lines, representing roads, &c.

4th. Roads in a hilly country generally have a curvilinear direction, for the purpose of keeping as nearly as possible in a horizontal plane; consequently, the lines representing these roads would coincide, or nearly so, with the lines representing the ground, in the *horizontal system*. In the *vertical system* these lines coincide only when the ascent is direct, which rarely occurs among hills.

5th. There is less difficulty in softening off the base and summit of a hill by the vertical than by the horizontal system.

6th. The angles, at which the vertical lines meet the beds of streams, express the direction and rapidity of the current.

7th. It is the style of the engraver, and therefore more suitable for drawings that are to be engraved.

The direction of the strokes or shading-lines, and method of determining that direction.

If a heavy body be rolled down a declivity, and acted upon by no other force than that of gravity, it will, according to the laws of that force, take the shortest direction to the horizontal plane, and consequently be perpendicular to the intersection of this plane with the surface of the declivity. This is the true direction of descent, and the one in which the shading line should be drawn to represent it correctly. Hence, in taking the plan of a hill, certain hrizontal lines on its surface must be determined to which the shading lines must be drawn perpendicularly. These horizontal lines or curves, are the intersection of the surface of the hill with a system of horizontal planes, and may be determined as follows:

Let S, (Fig. 4, Plate I,) be the summit of a hill, the base of which is marked by the curve ABCD. Determine by levelling, by vertical angles, or by some other modes, the heights of the points *a*, *b*, *c*, &c., (on the surface of the hill,) above a plane of reference which, in this case, is taken in the plane of the curve ABCD at the foot of the hill. Let us suppose the altitude of these points to be re-

spectively equal to 6, 10, and 14 feet. The inclination of the ground at these points must also be ascertained. Now construct a scale of inclinations from 0 to 45°, as shown in Fig. 3. Lay off AC upon AB equal to the intervals between the horizontal planes, which we will suppose to be 10 feet. Draw CE parallel to AD, and the intersection of this line with the lines forming the angles 5°, 10°, 15°, &c., will give the horizontal distances Aa, Ab, Ac, &c., of every pair of curves under corresponding angles of inclination. The point *a* being 6 feet above the plane of reference, will, therefore, be 4 four feet below the first curve. The inclination of the ground at this place is 15°, and by referring to the scale of inclination, it will be seen that Ag is the horizontal distance that the curves will be from one another at this angle. Divide this line into 10 equal parts, and lay off 4 of them above *a* in the direction *a m*, and it will give a point *m* in the first curve of intersection. And since the point *b* is just 10 feet above the plane of reference, it will be another point in the same curve. The point *c* having an altitude of 14 feet is, therefore, between the first and second curves, and as the ground at this place has an inclination

of 20°, it will be seen that Af, Fig. 3, is their horizontal distance from each other. By dividing this line into 10 equal parts, and laying off 4 of them below *c*, and the remaining 6 above the same, it will determine a third point *o* in the first, and a point *p* in the second curve. By proceeding in this manner any number of points may be found, and the lines drawn through those points, having the same altitude, will be the curves of intersection of the surface of the hill with a system of horizontal planes.

There are many other methods for determining these curves laid down in works on surveying, which it is thought unnecessary to insert here, as the one above is deemed sufficient for the illustration of our subject.

It is rarely the case in practice that this rigorous mode of laying down the curves is resorted to, unless it be for the purpose of a military site, a defilement, or some other work which requires the features of the ground to be determined with the utmost degree of accuracy. Generally it suffices to draw them by the eye, with reference to the marked heights of objects on the ground, without regard to the law of equal distances or of continuity,

and frequently we only imagine them, to guide the hand in drawing the shading lines. With a little practice one is enabled, by the eye alone, to draw these curves with sufficient precision to give the direction of the strokes.

All objects situated on the surface of the hill should be drawn at the same time as the curves, and with reference to them, whether they be laid down instrumentally, or by the eye.

The curves of intersection, being determined and traced on paper, we next proceed to draw the shading lines. This is done with a fine and tolerably stiff pen, commencing at the highest curve, drawing the strokes with a steady hand from left to right, and perpendicular to the next curve below. This row of shading lines should be continued around the hill, before another is commenced, as shown in Fig. 5, Plate I. Particular care should be taken in drawing the next, and every succeeding row that the lines do not intrude between those of the preceding, as in Fig. 7, or be separated by too great an interval, as in Fig. 8; for in either case, the consequence would be a bad effect to the drawing, and a false representation of the ground. For the same reasons, we should avoid leaving a

dot at the extremities of the lines, as in Fig. 9, which is generally caused by a bad pen, or the use of too much ink at once.

The second row of lines is commenced near the extremities of those forming the first, taking care to curve them gradually, so that they will fall perpendicularly upon the next horizontal curve. In the same manner should be drawn successively the remaining rows. The last row of lines should be tapered off so as to blend the surface of the hill with the plain beneath, and prevent a sudden transition which is never seen in nature; the upper extremities of the first row should also be softened as seen in Fig. 6.

If the curves be so far apart as to make it inconvenient to draw the strokes at full length, or cause too great a divergency, intermediate curves should be introduced, as *xy* and *tz*, Fig. 5.

When the strokes are made with a pen, the curves should be drawn with a pencil, and afterwards erased; but as the pencil only is used in sketching, they cannot be erased without destroying the shading-lines; they should therefore be marked in very lightly.

Method of expressing the inclination of a declivity.

The form of a hill is not determined solely by the direction of its surfaces, but also by the angles which they make with the horizon. When the light by which these declivities are illuminated is taken vertically, their angles of elevation may be expressed by the gradations of shade which the shading-lines can be made to produce. In this vertical illumination, the rays of light coincide with the visual rays, and are, therefore, perpendicular to the horizontal plane. This plane then receives the strongest light, because the reflected ray coincides with the vertical one; and since the angle of incidence is equal to the angle of reflection, that declivity which has an inclination of 45° is the least illuminated, because the reflected ray is parallel to the horizon. All intermediate surfaces would receive a due proportion of light according to their inclinations.

Now 45° is the greatest slope that it is necessary to mark in a topographical drawing, because this is the natural slope, and no hill of common earth can be steeper; even this inclination must constantly diminish from the effects of

weather. It is true, rocks have a greater inclination; for they are frequently perpendicular, and sometimes projecting; and therefore require a particular mode of representation, which we will give hereafter.

The horizontal plane and the slope of 45° are the extremes of inclination. If the former be expressed by the maximum degree of light or perfect white, and the latter by the maximum degree of shade or pefect black, the proportion of light to shade, for any intermediate angle, must be as its supplement to 45°, to the angle itself; thus, for example, the proportion of light to shade for a slope of 15° will be as 45–15 to 15, or as 2 to 1; that is the intervals between the strokes should be just double the size of the latter to express a surface inclined 15° to the horizon. By a similar proportion the size of the strokes to their adjoining spaces may be found for all inclinations between 0 and 45°. In the table below, this proportion is calculated for every five degrees.

SLOPES.	SPACES.	STROKES.
5°	8	1
10°	3½	1
15°	2	1
20°	1¼	1
25°	1	1¼
30°	1	2
35°	1	3½
40°	1	8

This method of expressing relative steepness by relative intensity of shade, though perfectly accurate in theory, is not readily reduced to practice; on the contrary, it requires of the surveyor a vast deal of time and labor; and of the draughtsman, the greatest skill and experience in drawing, and the utmost precision in estimating

minute proportions. Moreover, in the frequent copying of hills, even by the best draughtsman, they may be materially altered, either by an incorrect judgment of the degree of slope intended, or in the execution of the drawing. A slope of 10° may be easily taken for one of 15°, and be so represented in the drawing; the next person who copies this copy judges the 15° to be 20, and thus we should have in the second copy a slope of 20°, which in the original was only 10. This system is not therefore well adapted to the beginner or unskilful draughtsman, and requires some modification to render it of utility in practice.

Various alterations have been made in this system to render it serviceable; but none seems to answer the purpose intended so well as that which it has undergone in England. As it is generally used in that country, and considered preferable to any other, we give it here.

Instead of endeavoring to represent every degree of elevation, or even every five degrees, three general slopes only are required to be represented with precision; these slopes are, 15°, 22 1-2°, (the mean angle,) and 30°, which with the two extremes will regulate the shading of

hills in the most simple manner, and enable the beginner to be almost as serviceable as the experienced draughtsman; besides being sufficient for all practical purposes.

It will be perceived from what has been said, that the proportion of the interval to the stroke, to express an inclination of 15°, is as 2 to 1; in the mean angle 22 1-2°, the interval is equal to the stroke; and in the angle of 30°, the interval to the stroke is as 1 to 2. Hence, in viewing a topographical drawing made by this method, it follows:

1st. Wherever perfect white is seen, the ground is horizontal or nearly so, and perfect black shows an inclination of 45°.

2d. Wherever it is observed that the intervals between the strokes are double the size of the latter, the ground has an inclination of 15°, when they are equal there is an inclination of 22 1-2°, and when the size of the stroke is double that of the intervals, the ground is inclined 30° to the horizon.

3d. Wherever we observe the intervals to be more than double the size of the strokes, the ground has an inclination less than 15°, and *vice versa* the ground would have an inclination greater than 30°.

4th. Wherever the intervals are less than double, and not so much as equal to the strokes, the inclination of the ground is between 15 and 22 1-2°.

5th. Wherever the strokes are greater than the intervals, but not so much as double, the inclination is between 22 1-2 and 30°.

In drawing hills by this system, the draughtsman should first construct a scale of shade as shown in Fig. 10, Plate I.; which will guide him in giving equal sized strokes to different surfaces having the same angle of inclination, and thereby produce uniformity in his design. The size of the strokes is optional with the draughtsman, only they must be fine enough to give the drawing a connected appearance, at the ordinary distance of viewing it, and at the same time strong enough to be distinguished at that distance.

The great utility of a topographical drawing, in a military point of view, consists in enabling the officer to ascertain with sufficient accuracy what obstacles will be presented to his ascent, and to what extent the ground will admit of manœuvres.

In order to show what slopes it is necessary to notice in topographical drawings for military purposes, we annex the following table :

		CAVALRY.	ARTILLERY.	INFANTRY.
GRADATIONS ADMITTING OF MANŒUVRES.	5°	May move with order, and has up hill its most effectual shock.	Has a more effectual fire down, than up hill.	May move with order, and has, down hill, the most effectual fire and charge.
	10°	Can only canter down hill; the charge only possible up hill.	Moves with difficulty; its effectual and constant fire ceases.	Its close movements become more difficult.
	15°	May still trot up, and walk down hill.	Moves with great difficulty; its fire totally ceases.	Cannot move any considerable distance with order; their fire up hill without effect.
GRADATIONS WHICH MAY BE ASCENDED AND DESCENDED SINGLY.	20°	May still ascend, at a walk, and descend without order, and that only obliquely.		Cannot move in order, and can only fire singly with effect.
	25°	Light Cavalry may ascend one by one obliquely, and descend in the same way, but with great difficulty.		Light Infantry as before.
	30°	Light Cavalry may ascend as above, but with great difficulty, and when the slope is of soft earth.		Riflemen, as Light Infantry before.
GRADATIONS WHICH MAY BE CLIMBED UP.	35°			Riflemen may ascend with difficulty, one by one.
	40°			Riflemen without baggage may ascend with help of their hands.
	45°			Riflemen accustomed to hilly country may ascend as above, but with danger of falling.

Now although the modified system will not represent the ground for every 5° of slope, still it will show,

1st. The limit to the ground that admits of manœuvres.

2nd. Ground that may be ascended and descended by light cavalry.

3rd. Ground on which light troops only are effective.

This representation of the ground is generally minute enough for all purposes of the field.

CHAPTER III.

OBLIQUE LIGHT.

In the preceding chapter we have only considered a vertical light, a result that must occur whenever shade is made to express degrees of steepness, for it is evident that this could not be done under an oblique illumination, since the same declivity would have more or less shade, according as it was turned more or less towards the direction from whence the light came.

An oblique light is frequently preferred on account of the picturesque effect that is produced in the drawing, and the strong relief that light and shade afford to objects, enabling us to form a better idea of their shape and general character; the design too, becomes easy to understand, and acquires a degree of clearness which renders it intelligible even to those least accustomed to viewing topographical plans.

When an oblique light is used to illuminate a plan, it is the common rule to conceive it entering at the top left hand corner of the drawing, at an inclination of 45° to the horizon. We see, then, very easily, which are the parts necessary to be put in shade, and also those that must be left more or less in the light; we say more or less, because no declivity should remain entirely without shade; even that which is most directly opposed to the light, should have a slight one. The flat and horizontal parts only, should remain perfectly white, and these, however elevated, or situated in the depth of a valley, are represented in the same manner; which would be a great inconvenience, had we not the courses of water, and the shading of declivities to distinguish them. Should there, however, be any doubt on this point, it could be removed by covering with a light uniform shade, the depth of the valley, which being at a greater distance from the eye of the observer, should be less vividly illuminated than that which is nearer; for we know that the more objects recede from the eye, the more the lights and shades lose their intensity. The lights are weakened, and the shades pass to a half tint.

Should a case occur (which rarely happens) in which it is necessary to have recourse to this method of distinction, care must be taken that the shading be not overloaded so as to give to the drawing a dull, heavy appearance.

The oblique light is better for representing mountainous countries; for it often occurs that the two sides of a valley rise at equal angles of elevation, and shade, according to a vertical illumination, would not produce adequate relief, particularly when the same inclinations are of great extent.

We will remark here, that ground is always sketched as under a perpendicular light, whether the finished drawing is to be made under a vertical or oblique illumination.

The shadows of objects are commonly excluded from topographical drawings, but there are cases where they produce a very good effect. For instance, should we wish to detach a vertical wall, the shadow is an excellent way of doing so, or if we have to represent some special object, such as a column, monument, pyramid, &c., which would not be well indicated by the horizontal projection alone, we may have recourse to the shadow, Fig. 11,

Plate I. The shadow not only gives an idea of the form of the object, but offers a very simple way of measuring the height, which is equal to the length of its shadow, when the light is under an angle of 45°.

Buildings, woods, and banks of streams, are drawn with a strong line on the sides of these objects which lie in the shade. See *city* and *village*, Plate III.

Detached trees may be drawn with or without shadow; on level ground it produces a good effect, while on declivities it interferes with the shading lines. See *orchards*. Plate III.

Reflected light, which is a consequence of oblique illumination, is not considered in topographical drawing, as it would only be a source of difficulty to the draughtsman.

As inclination cannot be expressed by depth of shade under an oblique illumination, we make use of horizontal curves; these curves are marked in with the pencil, and erased after the shading lines are drawn; the small white spaces left between the rows are sufficient to indicate the horizontal curves.

It is optional with the draughtsman whether he

makes use of a vertical or oblique illumination, but as clearness is the most essential quality of a topographical design, it is better to sacrifice to the truth and reality produced by the latter, the advantage of representing relative steepness by relative intensity of shade which is offered by the former.

CHAPTER IV.

TOPOGRAPHICAL DELINEATION OF ROCKS.

THE representation of rocks may justly be considered the most difficult part of topographical drawing. The great variety of forms under which they present themselves, sometimes in large masses more or less rounded, frequently in a heap of fragments, here regularly disposed in layers nearly parallel, and there the same layers broken in a thousand ways, requires all the skill of the draughtsman to represent them correctly. The best rule that can be given is to imitate nature. And here a knowledge of landscape drawing is of a decided advantage; for rocks seen from an elevation, and represented in horizontal projection, present nearly the same features, as when viewed in perspective.

We have given in Fig. 2, Plate II., an example of rocks drawn in this manner.

The layers (which in this case are supposed to

be broken and cragged) are indicated by lines more or less parallel, according to their nature. Fig. 4. represent the same layers more regularly disposed.

Rocks drawn according to this method, should be as little labored as possible, for the perfection consists in producing the desired effect with a very few lines.

But to those who do not possess a knowledge of landscape drawing, we present another mode of representation, which is the use of short, thick lines arranged in masses, as shown in Fig. 6, Plate II.

In either of the above methods the rocks should be sketched in, before the shading lines representing the declivities are drawn, as in Figures 1. 3. 5, Plate II.

One circumstance regarding rocks it is necessary to mention here, because it depends upon an invariable law of nature, and which we every where meet with in a mountainous country; it is this, that whenever a stratum of rock presents a concavity, there is found beneath it, a cone of accumulated fragments which may be represented by divergent lines as seen in Fig. 2, Plate II. When the stra-

tum is of great extent, we observe beneath it a great number of these cones which, uniting with each other, form a general slope as represented in Fig. 4.

A knowledge of geology is of great assistance to the draughtsman, for if he understand the nature of rocks, he can better represent them.

CHAPTER V.

DELINEATION OF TOPOGRAPHICAL MINUTIÆ.

THUS far we have only treated of hills and rocks; but towns, fields, woods, marshes, water, &c., require to be attended to in their places. The principal topographical minutiæ are represented in Plate III.

Flowing water is represented by curvilinear lines drawn parallel to the shore, the intervals between them gradually increasing as they recede from it. Each line should be drawn its full length, before beginning another; for by frequently recommencing, the lines become of unequal size, which produces a bad effect. The two lines that represent the shore should be more strongly marked than the others.

When the shore is rocky the lines should be more curvilinear and angular, than when it is smooth and sandy.

Depth of water, or rapidity of the current, is

expressed by numbers. It has been attempted to express depth by bringing the lines closer to each other, and rapidity by making them more or less curvilinear; but by these means we obtain the relative not the actual depth and rapidity; therefore, numbers are to be preferred.

Standing water, as lakes, ponds, and pools in marshes, is represented by horizontal lines drawn from left to right. These lines may be drawn entirely across the surface of the water, or in short lines round the shore. See Ponds, Plate III.

Meadows are represented by small dots, arranged two and two. See Plate III.

Pasture is represented by tufts of grass scattered unequally over the surface. Plate III.

Heath is represented by tufts of grass, interspersed with bushes and shrubs, as shown in specimen.

Woods may be represented either in elevation or projection; see specimen, Plate III. The former mode is the better, for by it they are more easily understood. Isolated trees should always be drawn in elevation, for when drawn in projection, particularly on a small scale, they are apt to be taken for other objects. Woods on declivities

are represented in projection, but care should be taken that they do not interfere with the lines indicating the slope of the ground; for this reason the trees are drawn previous to the shading lines, as shown in Fig. 5, Plate II. The shading lines must be limited to the outlines of the trees and not drawn across them.

A wood may be represented as open, thick, or impenetrable. An open wood is represented by small masses of trees, or single trees scattered irregularly; if it be thick, increase the size of the masses, and diminish the number of those that are detached; if it be impenetrable, it may be expressed by one entire mass.

Brushwood is represented by bushes and shrubs, drawn as in specimen.

Cultivated ground may be represented by fine stippled lines parallel to each other. If it be on the side of a hill, these lines should have a curvature corresponding to the surface of the ground.

Gardens are represented as cultivated ground, but laid out in a more ornamental manner, and interspersed with walks, trees, &c. See specimen.

Orchards are represented by trees placed in

parallel rows; if the shadows be drawn, it increases the effect. See specimen.

Sand is represented by dots. A specimen of sandy shore is given in Plate III. Sand and stones mixed together are shown by dots of unequal size.

Cotton, Tobacco, Rice, and *Sugar plantations,* are represented as in specimens, Plate III.

Vineyards are shown by poles encircled by vines. In *Hop-grounds* the vines are turned in a contrary direction. See specimens.

Fresh Marsh is represented by pools of water, interspersed with grassy clumps of earth, as in specimen.

Salt Marsh is represented by horizontal lines with here and there a tuft of grass. See specimen.

Deep Morass is represented in the same manner as a fresh marsh with the addition of a few flags and bushes. See specimen.

Everglades are represented as deep morasses, with the addition of a few palmettoes.

Inundations are shown by first faintly representing the country, over which lines indicating water are drawn. See specimen.

Cornfields are represented by a number of parallel lines, arranged as in specimen. They are only distinguished in plans drawn on a large scale.

For the *Geographical* and *Military Signs*, see Plates IV. and V.

CHAPTER VI.

METHOD OF SKETCHING GROUND.

In sketching ground the beginner will find more difficulty than in copying with the pen, and in order to be able to make the strokes with accuracy and ease, it is necessary to practice drawing them at first between the horizontal curves; after being well exercised in this, the strokes may be drawn without their assistance—yet without departing from that rule which fixes the direction of the strokes in that of greatest descent.

The same rules that have been given for drawing the shading lines with the pen, will also apply to the pencil in sketching.

Let us suppose that we are going to sketch a small hill unconnected with any other, and of which S, Fig. 1, Plate VIII., is the summit. We first trace (either with instruments or by the eye) the inferior curve, *a b c d*, and afterwards others between it and the summit. These curves may be

continued or broken according to the nature of the ground. After they are traced, other objects situated on the hill side, such as houses, trees, fences, &c., should be drawn.

The curves being traced, draw the shading lines perpendicularly to them. These lines should always be drawn from left to right, and towards the breast of the draughtsman. If he be on the summit of the hill, he should commence at the foot directing them towards the top, as shown in Fig. 3, Plate VIII. If he be situated at the foot, it will be the reverse as in Fig. 4.

We will repeat the observation made in a preceding chapter, that the curves should be traced lightly, as they cannot be erased without destroying the shading lines.

A cavity of the same form as an elevation is represented in the same manner, and therefore not easily distinguished from it, were it not that the edges of a cavity are more abrupt than the bottom; the shading lines should therefore commence abruptly at the top as in Fig. 5, and be softened towards the bottom. This difficulty would not occur under an oblique illumination, for that part of a hill which is in the light would in a cavity be in the shade, but

as we always sketch under a perpendicular light, recourse must be had to the former mode of distinction.

When a cavity is much lengthened, there is commonly found at its bottom a stream of water; this alone would prevent confounding the depth of the cavity, with the crest of a mountain, even if there were in other respects some resemblance in their forms.

We will remark that water-courses are perhaps the most sure and simple way of showing, not only the lowest parts of a locality, but also the nature of the bordering declivities, by their proximity to the ridges: for in general, when a ridge separates two valleys, the narrower is the steeper side, and if this be not always strictly true, it is because the greater depth of one of the valleys is the reason of its greater width. It is a rule, without exception, that for the same valley bordered by ridges of the same height, the side which presents the most width is the gentlest. But to return to our subject.

When there are two tops to the same hill, as seen in Fig. 6, Plate VIII., there is found between them a gutter or ravine which is marked by the re-entering form of the horizontal curves. The

shading lines here are difficult to make, for they will meet and cross each other if care be not taken to make them very short. It is necessary to multiply the horizontal curves in this place more than in the convex parts.

It is often the case that a gentle declivity is succeeded by one of steep descent which has nothing in common with the first. See Fig. 1, Plate IX. The curves of the one are not the continuation of those of the other; there is then an abrupt change in the direction of the shading lines, which takes place at the line *a b c* of intersection of these surfaces. This line should be indicated by some strong touches. These sudden changes commonly occur on the banks of rivers, and are occasioned by the wearing away of the earth by the current. The ground, in such cases, is represented by lines drawn perpendicularly to the course, as seen in Fig. 1, Plate IX. If there be no wearing away of the earth, the shading lines near the borders should turn insensibly in the direction of the stream, which is evidently the line of greatest descent. See Fig. 2, Plate IX.

When the ground has but little curvature, the shading lines are nearly parallel to each other, and

it is evident that in representing an inclined plane, they will be strictly so, because the horizontal curves degenerate into right lines. Fig. 5, Plate IX. But we rarely meet with this case. Those declivities which have the most uniform appearance, still show slight inequalities, which, by allowing some divergency to the strokes, take away the disagreeable monotony of parallel lines.

In sketching groups of hills, particular attention should be paid to the just connection of their declivities; for if this be not properly observed, the descent of the ground, in those parts, will be incorrectly represented.

A steep declivity is expressed by the shading lines being drawn short and close, as in Fig. 3, Plate IX., while, on the contrary, a gentle slope is represented by lengthened lines, separated at greater intervals. Fig. 4, Plate IX. This gives, to a certain degree, the relative inclination of the ground, which is all that can be expected from a sketch. The actual angle should be put down in numbers, and when the finished drawing is made, the inclination may be expressed by the shading lines, or horizontal curves, according as it is made under a vertical or oblique light.

After having made a number of sketches, with the assistance of horizontal curves, we should endeavor to represent the ground by the shading lines alone; knowing what ought to be the form of the horizontal curves, if traced, we shall be able to give them their true direction. Without this guide, the drawing would present inaccuracies.

Until now we have given examples of uniform ground, which are rare. Ground generally presents some sinuosities more or less decided. These are represented by short close lines, drawn with a blunt pencil, as shown in Fig. 7. Rocks may be represented in this manner or as in Fig. 6.

The shading lines being only a conventional way of representing ground without prejudice to the objects situated upon it, care should be taken that they be not drawn so black, as to conceal or obscure those objects which it is important to distinguish, and thus render the sketch confused or unintelligible. This method of overloading a drawing with shade, is frequently resorted to for effect, and it is the worst fault into which a draughtsman can fall, for it takes away that clearness which is so essential in a topographical sketch.

In military sketching, which is usually done in great haste, a few strokes only are made to represent the ground as shown in Plate X.

Plate XI. is a topographical sketch of Fort Putnam, and is introduced as a good example of a rocky hill. It would be well for the pupil to copy this often, to get a free use of the pencil, as well as to learn the manner of sketching rocks.

Little more can be said on sketching. Practice alone will render a person expert, and produce that freedom of the hand, and certainty of the eye, which are so necessary to the natural and correct delineation of ground.

CHAPTER VII.

TOPOGRAPHICAL SCALES.

TOPOGRAPHICAL maps are distinguished from topographical plans by their scales; the former being usually constructed on scales from half to one inch to the mile, the latter on scales greater than one inch, but very seldom exceeding 12 inches to the mile.

A topographical map constructed on a scale of one half inch to a mile will admit of the representation of all towns, villages, main roads, the principal cross roads, and every considerable hill and stream. On a scale of one inch to a mile, there can be represented all towns, villages, farms, woods, isolated buildings, every stream of 600 feet in length, and every hill of 100 feet in height, and 500 or 600 feet in horizontal extent.

On a topographical plan of two inches to a mile, the various features of the ground can be clearly and accurately represented; as also every stream hav-

ing a length not less than 300 feet, every pond not less than 50 feet broad, and all towns, villages, farms, woods, roads, foot-paths, isolated buildings, &c.

The scale of six inches to a mile is the best for military purposes, and is the most suitable for the complete delineation of a country. Scales larger than this are generally used for plans of estates, towns, villages, ruins, roads, canals, &c.

To construct a diagonal scale. Let AB, Fig. 7, Plate VII., be equal to one inch, and it is required to construct a scale, so as to give one hundredth of this line. At the points A and B, erect the perpendiculars AD and BC, lay off AD equal to AB, and draw DC parallel to AB. Divide AB and BC, each into ten equal parts, and through the points of division, .01 .02 .03 .04, &c., draw lines parallel to AB. Join .9 with D, and through the points .8 .7 .6 .5, &c., draw parallels to .9D, and the scale will be constructed, the divisions of which will count to one hundredth of AB. Suppose now $\frac{15}{100}$ of AB, are required. Place one point of the dividers at .05, and extend the other leg until its point falls at x; x.05 will be equal to $\frac{15}{100}$ of AB.

Scales should always be made on paper, and of

the same kind as that on which the plan or map is to be constructed, for it will then expand and contract in the same proportion, and consequently make the work more correct.

CHAPTER VIII.

METHOD OF DRAWING A PERSPECTIVE VIEW FROM A TOPOGRAPHICAL PLAN.

It is sometimes desirable to put a topographical plan in perspective, and in order that those unacquainted with the rules of perspective, may be able to do so, we will insert here the geometrical construction.

Let us suppose S, Fig. 1, Plate VI., and which is called the point of sight, to be the position of a spectator, looking in the direction SN, which we will call the line of sight. Draw through S the lines S*m*, and S*n*, making any angle *m* S*n* with each other. It is now required to put in perspective that portion of the plan comprehended within this angle. Lay off on SN, any distance SD, in front of the spectator, and draw AG perpendicular to the line of sight. Divide AG, and DN, into any number of equal parts, and through the points of division draw lines parallel to AG, and DN,

so as to divide the surface of the plan into squares. Now there must be put in perspective as many squares as there are squares in the plan.

Let *ag*, Fig. 2, be assumed as the base of the picture. This line may be equal to the base of the perspective plane AG, Fig. 1, or greater or less to any extent, but it must be divided into the same number of equal parts, and thus a scale will be formed for all the objects in perspective.

From the middle of *ag*, erect the perpendicular *d*E, equal to the required height of the eye above the horizontal plane, and through E, draw *m*E*n* parallel to the base of the picture. Lay off on this line either to the right or left of E, a distance E*m*, equal to the distance of the eye from the perspective plane, which in this case will be equal to half of AG, since the angle at S was taken a right angle, and consequently SD being equal to DG, E*m* must be equal to *dg*. Had the angle at S, been less than a right angle, the point *m* would have fallen at some point *o* between *m* and E.

Now divide *ag* into six equal parts, corresponding to the number of AG, and through the points of division, *a*, *b*, *c*, &c., draw lines to the point of sight E, and these lines will be the perspective of

the vertical lines AK, BL, CM, &c., of the plan. From the point of distance *m*,* draw the line *ma*, and through the points of intersection *p*, *q*, *r*, &c., draw parallels to the base of the picture, which will each complete as many squares as there are vertical divisions.

To obtain other squares beyond the triangle which is included between the base AG, and the spectator S, produce *ag*, in the direction *gk*, and lay off the distances *gh*, *hi*, *ik*, &c., equal to the divisions of *ag*, and through the points of division draw lines to the point of sight E. Then through the points of intersection with *am*, draw other horizontal lines; these lines will form with the vertical lines the perspective of other squares. In this manner may be put in perspective as many squares as there are squares on the plan, and then the ground plan of any object within each geometrical square, may be laid down in its corresponding perspective square.

Altitude is represented, according to perspective diminution, by measuring the given height on the horizontal side of that square which includes the ground-plan of the object.

* The point of distance is the distance of the spectator from the perspective plane, and is sometimes called the vanishing point of diagonals.

CHAPTER IX.

OF THE MERIDIAN LINE.

It is impossible to form a just idea of the situation of objects, without the true north and south line; neither can the same survey, made on different sheets, be readily united without it. This line should therefore be laid down on every map or plan, and as the variation of the needle is uncertain, we will insert here a very simple method of determining it by the sun.

From the extremity of a slender rod, attached to a table and inclined 30 or 40°, suspend a plummet so as nearly to touch the surface. The table must then be conveyed to some point laid down on the plan, and be made truly horizontal. At 9 o'clock A. M., and at 3 o'clock P. M., mark the extremity of the shadow cast by the rod, and draw a line from each of these points, to the point immediately under the plummet. If the watch be correct, these lines will be of equal length, and the

line bisecting the angle formed by them, will be the true meridian. This line may be determined without the assistance of a time-piece, by marking the extremity of a shadow some hours before mid-day, and the shadow which is of the same length in the afternoon.

This line, which is now determined on the table, may be connected with the ground, by placing the edge of a rule against the line, and looking along it to any object on the horizon with which it coincides. If this object happen to be one laid down on the plan, the line joining it with the station will be the true meridian; if it be a point not on the plan, the angle between it and any fixed point must be observed, and then by protracting the angle, the direction of the meridian may be laid down.

CHAPTER X.

TO MARK OFF THE MERIDIANS AND PARALLELS OF LATITUDE.

In order to mark off the meridians and parallels of latitude, it is necessary to know the latitude and longitude of at least one point on the map or plan, and also the direction of the meridian.

If the map or plan comprehend an extent of country not exceeding 100 miles square, the meridians and parallels of latitude may be expressed by parallel straight lines, if it exceed this limit, they must have their just curvature. We will first consider the former case.

Let AMFP, Fig. 3, Plate VI., be a map or plan, of which SN is the direction of the meridian, and x the situation of the known point, which we will suppose to be 4°. 16′ west longitude, and 47°. 18′ north latitude. Now as the meridian for every 10′ is required, the first on the right of SN being 4°. 10′ must be drawn at the distance of 6′ from x, and the first on the left of SN being 4°. 20′ west longitude,

must be drawn at the distance of 4′ from x. These distances, in the geographical measure of degrees, must next be reduced to the measure of length that has been employed in the survey, which we will suppose to have been taken in English miles.

The annexed Tables, I. and II., give the geographical measure of degrees, and the same reduced to English statute miles.

TABLE I.

Showing the length of a degree of longitude for every degree of latitude, in geographical miles.

Lat.	Geog. miles	Lat.	Geog. miles	Lat.	Geog. miles	Lat.	Geog. miles
0	60.00	23	55.23	46	41.68	69	21.51
1	59.96	24	54.81	47	41.00	70	20.52
2	59.94	25	54.38	48	40.15	71	19.54
3	59.92	26	54.00	49	39.36	72	18.55
4	59.86	27	53.44	50	38.57	73	17.54
5	59.77	28	53.00	51	37.73	74	16.53
6	59.67	29	52.48	52	37.00	75	15.52
7	59.56	30	51.96	53	36.18	76	14.51
8	59.40	31	51.43	54	35.26	77	13.50
9	59.20	32	50.88	55	34.41	78	12.48
10	59.08	33	50.32	56	33.55	79	11.45
11	58.89	34	49.74	57	32.67	80	10.42
12	58.68	35	49.15	58	31.79	81	9.38
13	58.46	36	48.54	59	30.90	82	8.35
14	58.22	37	47.92	60	30.00	83	7.32
15	58.00	38	47.28	61	29.04	84	6.28
16	57.60	39	46.62	62	28.17	85	5.23
17	57.30	40	46.00	63	27.24	86	4.18
18	57.04	41	45.28	64	26.30	87	3.14
19	56.73	42	44.95	65	25.36	88	2.09
20	56.38	43	43.88	66	24.41	89	1.05
21	56.00	44	43.16	67	23.45	90	0.00
22	55.63	45	42.43	68	22.48		

TABLE II.

Showing the length of a degree of longitude for every degree of latitude, in English statute miles.

Lat.	Eng. miles	Lat.	Eng. miles	Lat.	Eng. miles	Lat.	Eng. miles
0	69.2000	23	63.6986	46	48.0705	69	24.7992
1	69.1896	24	63.2177	47	47.1944	70	23.6678
2	69.1578	25	62.7167	48	46.3038	71	22.5294
3	69.1052	26	62.1963	49	45.3994	72	21.3842
4	69.0312	27	61.6579	50	44.4811	73	20.2320
5	68.9363	28	61.1001	51	43.5489	74	19.0743
6	68.8208	29	60.5237	52	42.6037	75	17.9103
7	68.6845	30	59.9293	53	41.6453	76	16.7409
8	68.5267	31	59.3162	54	40.6751	77	15.5665
9	68.3481	32	58.6851	55	39.6917	78	14.3874
10	68.1489	33	58.0360	56	38.6959	79	13.2041
11	67.9288	34	57.3696	57	37.6891	80	12.0166
12	67.6880	35	56.6852	58	36.6705	81	10.8250
13	67.4264	36	55.9842	59	35.6408	82	9.6306
14	67.1448	37	55.2659	60	34.6000	83	8.4334
15	66.8424	38	54.5303	61	33.5489	84	7.2335
16	66.5192	39	53.7788	62	32.4873	85	6.0315
17	66.1760	40	53.0100	63	31.4161	86	4.8274
18	65.8134	41	52.2259	64	30.3352	87	3.6219
19	65.4300	42	51.4253	65	29.2453	88	2.4151
20	65.0265	43	50.6094	66	28.4464	89	1.2075
21	64.6037	44	49.7783	67	27.0385	90	0.0000
22	64.1609	45	48.9313	68	25.9230		

Now one degree of longitude, in the parallel of latitude of 47°, being equal, according to Table I, to 41 geographical miles, the respective lengths of the difference of longitude between NS and *kq*, and NS and *ip*, are found in geographical miles by the following proportions;

60′: 41 miles :: 6′: $4\frac{1}{10}$ geog. miles = *xb*

60′: 41 miles :: 4′: $2\frac{11}{15}$ geog. miles = *xa*

Take these two lengths in the scale of the map

and set them off, the first from x to b, the second from x to a, and draw through the points a and b the line kq, and ip, for the meridians of 4°. 10′ and 4°. 20′. The other meridians are found by setting off the distances bc, cd, af, &c., equal to ab, and through the points c, d, e, f, &c., drawing parallels to NS.

The parallels of latitude are determined in a similar manner. The point x being 47°. 18′ north latitude, that of 47°. 20′, will be 2′ north of x, and the parallel of 47°. 10′ will be 8′ south of x. The lengths of the differences of latitude, xz and xy, will be obtained in English statute miles by the following proportions;

60′: 69¼ miles :: 2′ : 2 miles 542¾ yds. = $x z$.

60′: 69¼ miles :: 8′ : 9 miles 410¾ yds. = $x y$.

By laying off the respective lengths of xz and xy, upon NS, and through the points z and y, drawing parallels to WE, they will represent the parallels of latitude for 47°. 10′ and 47°. 20′. The remaining parallels are found by making the distances between them equal to yz.

Now let ABCD, Fig. 4, Plate VI., be a map in which is comprehended an extent of country exceeding 100 miles square. We will suppose this

map to contain an extent of country between 1° east, and 5° west longitude, and 25 and 31° north latitude. Let SN be the direction of the meridian, and the point *a* situated 28°. 20′ north latitude, and 1°. 30′ west longitude. Find in the same manner as shown above, the difference of latitude between the point *a* and 28 and 29°. Lay off respectively these distances towards S and N. Let *eb* be the length of a degree of latitude thus determined; lay off this distance twice from *b* towards N, and three times from *e* towards S, and the point *x* will be situated in the latitude of 25°, and the point *y* in that of 31°. Through the points *x* and *y* draw the lines *cyd*, and *gxh*, perpendicularly to SN. Now the length of a degree of longitude in the parallel of latitude of 31° (see Table I,) is 51.43 miles; set off *yd* equal to one half this length, and *yc* equal to the remaining half; and the length of a degree of longitude in the latitude of 25° being equal to 54.38 miles, set off *xh* equal to one half this length, and *xg* equal to the remaining half. Draw the lines *dh* and *gc*, and through the points of division of the line SN draw lines at right angles to SN, which will divide *hd* and *gc* into the same number of degrees.

Then *ghdc* will be the projection of 1° of longitude including 6° of latitude. The remaining meridians may be determined as follows. From the points *g* and *h* as centres with a radius equal to *hc* or *gd*, describe the arcs *dm* and *ik*, and from the points *c* and *d* with the same radius describe the arcs *vz* and *tu*. Now from the points *c* and *d* as centres, with a radius equal to *cd*, describe two arcs intersecting the first at *m* and *i*, and from *h* and *g* with a radius equal to *gh* describe two arcs intersecting *vz* and *tu* in *v* and *u*. Then draw the lines *vm* and *ui*, for the meridian of 0 and 3° west longitude; divide these into degrees of latitude, and draw parallels from the points of division to the corresponding ones in the meridian *gc* and *hd*. Proceed in this manner with the meridians *sl* and *zn*.

CHAPTER XI.

PROBLEMS FOR REDUCING, ENLARGING, AND COPYING MAPS OR PLANS.

To construct a square that shall be equal to any multiple of a given one.

Let ABCD, Fig. 4, Plate VII., be the given square, and it is required to construct one that shall be 2, 3, 4, &c., times its superficial surface. Draw the diagonal BD, and lay off B*a* equal to BD, and the square described upon B*a* will be double the square ABCD. Set off AE equal to B*a*, and draw BE and the square described upon BE or B*b* will be three times the square ABCD. In the same manner AF being set off equal to B*b*, the square described upon BF or B*c* will be equal to four times the square ABCD. And thus may be found any multiple of ABCD.

To construct a square that shall be equal to ½, ⅓, ¼, &c., *of a given one.*

Let ABCD, Fig. 5, be the given square on AB,

as a diameter describe the semi-circle AHB, and at the centre E erect the perpendicular EH, then draw BH and it will be the side of a square equal to $\frac{1}{2}$ of ABCD. Lay off FB equal to $\frac{1}{4}$ of AB, and erect the perpendicular FI, and the square described upon IB will be equal to $\frac{1}{4}$ of ABCD. In the same manner a square may be constructed equal to any part of ABCD.

To construct a square that shall be in any proportion to a given one.

Let us suppose that the square to be constructed shall be to the given one ABCD, Fig. 6, as 2 to 5. Upon the side AB as a diameter, describe the semi-circle AGB, and divide the line AB into five equal parts. At the second division erect the perpendicular FG, and join AG; the square described upon AG will be to the given square ABCD, as 2 to 5.

To reduce or enlarge a map from one scale to another.

Let ABCD, Fig. 1, be a map that it is required to reduce from a scale M to a scale N, Fig. 3. Divide the map ABCD into as many squares as it is thought necessary. Draw *ab* and *ad*, Fig. 2,

at right angles to each other. Lay off on *ab* as many parts of the scale N, as AB contains parts of the scale M, and in like manner lay off on *ad* as many parts of the smaller scale as there are parts of the larger scale in AD. Draw *dc* parallel to *ab*, and *bc* parallel to *ad*, then divide the rectangle *abcd* into as many squares as are contained in the map ABCD, and afterwards construct in every square that which is contained in the corresponding square of the given map. In the same manner the smaller map *abcd* could be enlarged from the scale N to the scale M.

If it were required to construct the map *abcd*, so as to be equal to ½, ⅓, ¼, &c., of ABCD, it would be necessary first to find, by one of the preceding problems, the side of a square that would be equal to ½, ⅓, ¼, &c., of one of the squares contained in ABCD, then by laying off on *ab* and *ad*, as many times the side of this square as there are divisions on AB and AD, and afterwards through the points of division drawing parallels to *ab* and *ad*, as many squares will be formed as there are squares in ABCD, the sum of which would be equal to ½, ⅓, ¼, &c., of ABCD.

Besides the method of reducing and enlarging maps, by proportional squares, the pentegraph and proportional compasses are used to great advantage for the same purpose.

CHAPTER XII.

FORMATION OF LETTERS.

THE formation of letters is not entirely unimportant, in a topographical drawing. When well or ill made, they increase or diminish the effect and beauty of the piece. It is well, therefore, to exercise one's self a little in constructing them.

The size of the letters ought to be, to a certain degree, proportional to the size of the drawing, and the scale on which it is made; but as no precise rule can be given on this point, it must be left, in a great measure, to the taste of the draughtsman. All that we can say is, that it is better to make them too small than too large. At all events let them be distinct.

The space that the letters should occupy being determined, rule it into squares and construct the letters as in Plate II.

The names of the principal objects, such as cities, towns, lakes, &c., should be written larger

than those of less importance, as villages, brooks, farms, &c. The names of water-courses and roads are written in their direction, but the names of cities, towns, villages, farms, &c., are written horizontally.

In placing the names on the plan, care must be taken that no part of the topography be altered or obscured by the letters.

APPENDIX.

To determine heights barometrically. Heights are determined by the barometer, on the principle that the density of the air decreases in a geometrical progression as we ascend, the increment of ascent being in an arithmetical progression. The barometer being an instrument which shows the density of the air at any time and place, it follows that if two barometers be placed at different altitudes, and simultaneous observations on them be made, the difference of altitude will be found, since the law of progression is known. But as the air is rarified by heat, which is sometimes different on different levels at the same time, which causes the length of the barometic column to be affected at the rate of .00296 English inches for every degree of Fahrenheit's thermometer, it therefore becomes necessary to have an attached thermometer to show the heat of the instrument, and a detached thermometer to show that of the surrounding air. These circumstances render the formula somewhat complicated. It is not our intention to demonstrate the manner in which every term of it is obtained, but simply to give the formula and an application.

FORMULA.

$(10000\,l \pm 468d) \times (1+(m-32°)\,.00245)$

l = difference of logarithms of heights of barometer.

d = difference of degrees of attached thermometer.

m = mean of the two temperatures shown by the detached thermometer.

When the attached thermometer is highest at the lowest station the negative sign is used, and when lowest at that station the positive sign.

We will now make an application of the formula.

	Barom.	At. Ther.	Det. Ther.
Ob. at lowest station,	28.42	50.6	48
Ob. at highest station,	28.21	58.2	58.9
		7.6 = d.	2)106 9
			53.45 = m

Log. 28.42 = 1.453624
Log. 28.21 1.450403

0.003221 = l

Then $10000\,l = 10000 \times 0.003221 = 32.21$
$+468\,d = 468 \times 7.6 = 3.5568$
$m-32° = 53.45 - 32 = 21.45$

Substituting these values in the formula it becomes:

$$(32.21 + 3.5568) \times (1 + (21.45).\ 00245) =$$

47.2872 fathoms or 283.72. feet, the difference of level required.

In the above formula the result is always in fathoms, which being multiplied by 6 reduces it to feet.

MEASURES OF DIFFERENT COUNTRIES.

Geographical miles in a degree	60
English miles	69¼
Scotch miles	61⅓
Irish miles	54⅓
German miles	15
Dutch miles or leagues	19
Prussian miles	16
Hungarian miles	13⅓
Danish miles	14¾
Norwegian and Swedish miles	10½
Tuscan and Milanese miles	67
Italian miles	60
Piedmontese miles	48
Ancient Roman miles	75
Grecian miles used in the Archipelago about	95½
Grecian miles used in Turkey, each 4232½ Eng. feet	88
Mil Kebir, or great Arabic mile,	50
Mil Sogair, an Arabic measure	95½
Giam, an Arabic measure, each = nine great miles	5⅝
Marine league	20
French league	25
Spanish league of 7572 varras	17½
Portuguese league	19
Turkish agach or league	22
Turkish berri	66½
Great parasangs or Persian leagues	17
Common parasangs	25
Japanese leagues	33½

Russian wersts	104¼
Hindoostanee coss, Northern provinces	36½
Indian coss, in Delhi	34½
Sultany coss	17½
Mogully coss	41
Royal coss	26¼
Carnatic coss	37½
Brammy or Punjaby coss	56
Malabar Gau	10
Siam Roening varies from 20 to	33
Chinese modern li	334

French metre = 39.771 English inches.

1609.32 metres = 1 English mile.

Old French foot = 12.78933 English inches.

" " toise = 6.394665 English feet.

Fig. 2.

Fig 3.

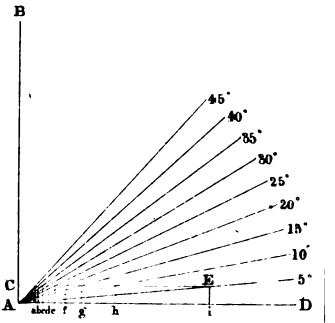


Fig. 5.

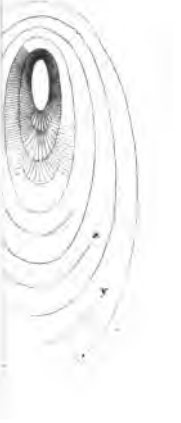
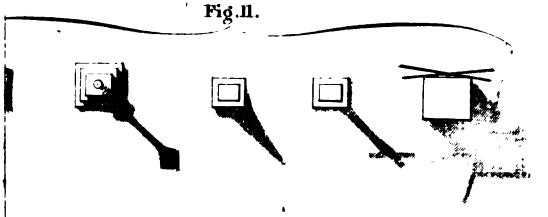


Fig. 6

Fig. 8.

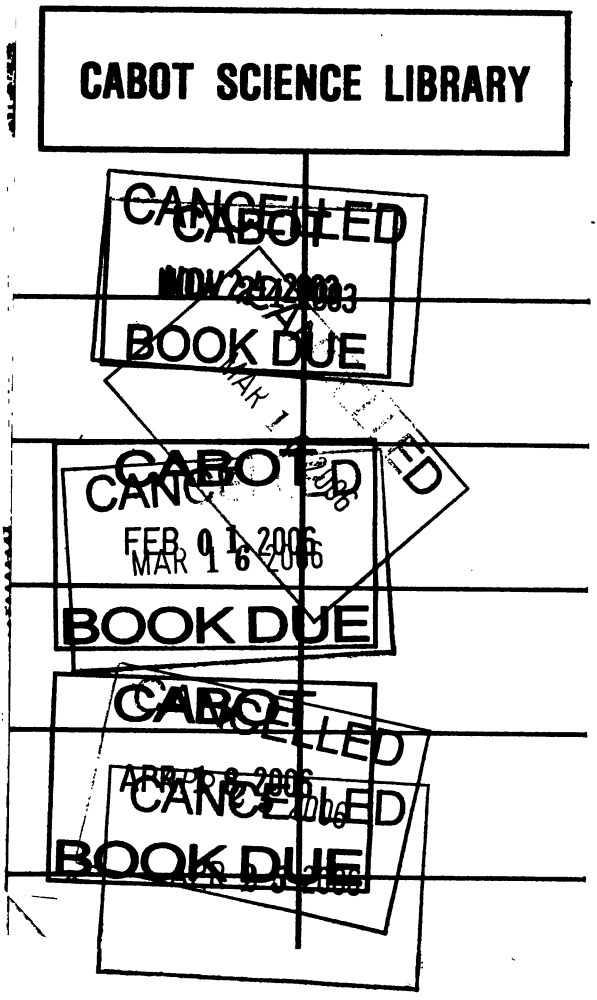
Fig. 9.

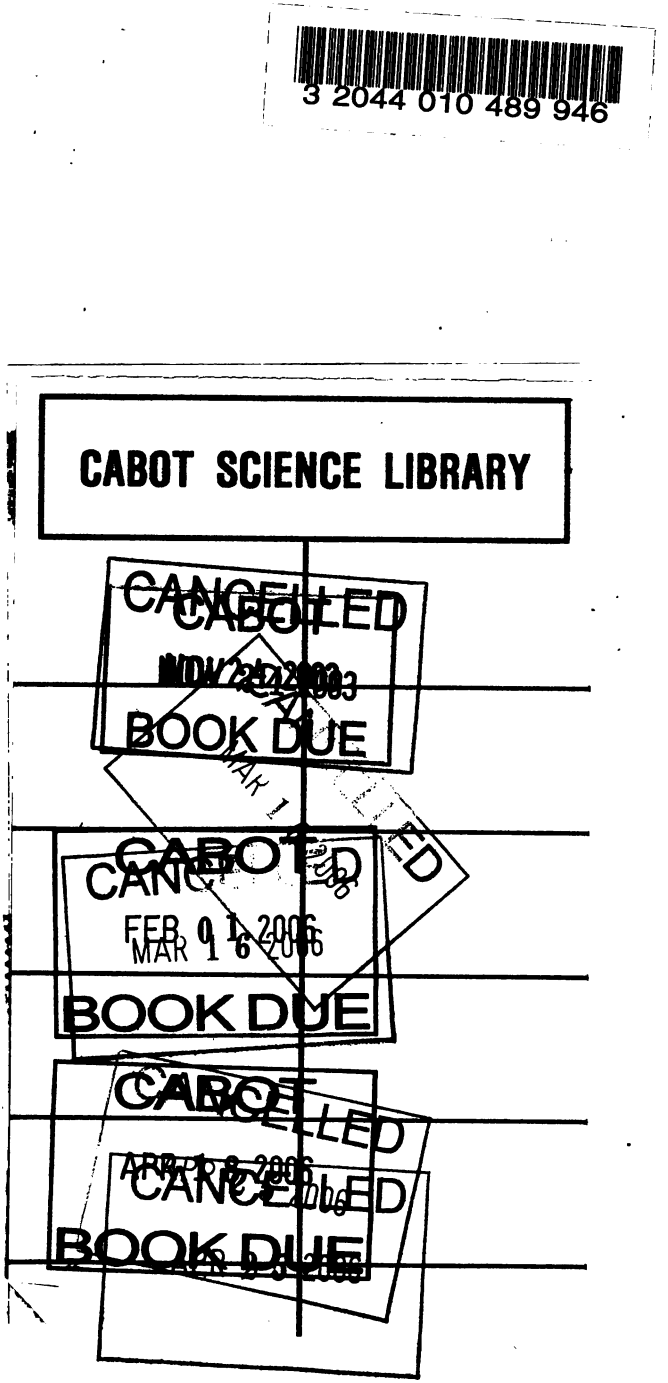
Fig. 11.



J.F.K. Prud'homme Direct

3 2044 010 489 946




3 2044 010 489 946
CABOT SCIENCE LIBRARY
CANCELLED
BOOK DUE
CANCELLED
BOOK DUE
CANCELLED
BOOK DUE